Armed Forces College of Medicine

AFCM

Mechanics of respiration

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INTENDED LEARNING OBJECTIVES (ILOs)

By the end of this lecture the student will be able to:

1- Describe the mechanics of normal and forced inspiration.

2- List the muscles involved in normal quit inspiration as well as forced inspiration

3- Describe the mechanics of expiration.

4- List the muscles involved in forced expiration.

5- Explain the intra-pleural pressure changes during breathing as well as the intra-alveolar pressure changes

6- Explain the causes of negative intra-pleural pressure and its

Introduction

Respiratory cycle is composed of:

1. **Inspiration:** movement of air from atmosphere to alveoli.
2. **Expiration:** movement of air from alveoli to atmosphere.
3. **Expiratory pause**

Respiratory rate 12-16 breath/min

Inspiratory Muscles

Role	Function	Inspiratory muscles
The primary muscle of inspiration.	- Responsible for 75% of change in chest volume. -Descends downwards→ ↑ vertical diameter of thoracic cavity.	1) **Diaphragm**
Secondary complementary role to diaphragm.	Run obliquely downwards & forwards from rib to rib. Contraction→ ↑ both antero-posterior and lateral diameters of the thoracic cavity.	2) **External intercostal muscles**
Only during **forced inspiration**	Elevate sternum & first two ribs→ enlarging upper portion of thoracic cavity.	3) **Accessory inspiratory muscles:** Scalenus, sternomastoid & Anterior serratus muscles

Expiratory Muscles

Role	Function	Expiratory muscles
Only during **active (Forced) expiration.**	↑ intra-abdominal pressure→ pushing the diaphragm upwards→ ↓ vertical diameter of the thoracic cavity.	1) **Abdominal muscles**
Only during **active (forced) expiration**	Run obliquely downwards & backwards→ Flatten thorax by pulling ribs downwards and inwards→ ↓ transverse diameter of the thoracic cavity.	2) **Internal intercostal muscles**

Important Pressures For Ventilation

Atmospheric pressure:

- The pressure of air surrounding the body = **760** mmHg at sea level.
- It is considered **0** mmHg when other pressures are related to it.

Intra-alveolar (Intra-pulmonary) pressure:

- It is the pressure **inside** the alveoli during respiratory cycle.
- It equilibrates with the **atmospheric pressure** because the alveoli are in direct communication with the atmospheric air, so air will move from the higher pressure to the lower one.
- During **inspiration: -1 mmHg** below atmospheric pressure.
  During **expiration: +1 mmHg** above atmospheric pressure.

IMPORTANT PRESSURES FOR VENTILATION

- **Intra-pleural (Intra-thoracic) pressure:**
  - It's the pressure between the **visceral & parietal** layers of the pleura.
  - There is **no** direct communication between the intrapleural and atmospheric pressures.

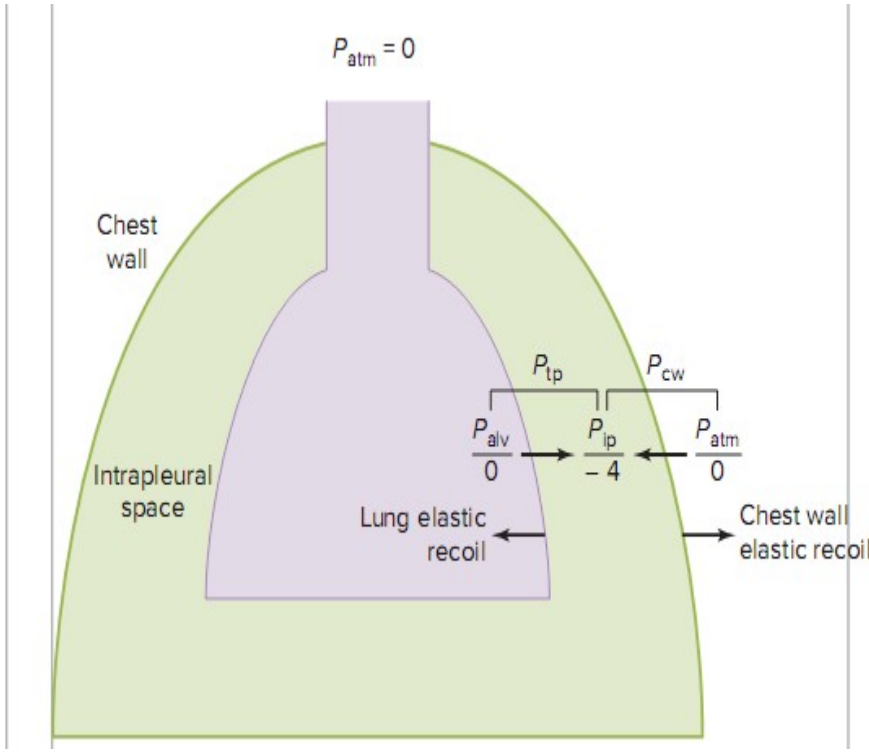
Values:

-4 mmHg= At the **beginning** of inspiration / **end** of expiration.

-6 mmHg = At the **end** of inspiration.

-30 mmHg= In **forced inspiration**.

+40 mmHg= In **forced expiration**.



VANDER'S HUMAN PHYSIOLOGY, 2016

IMPORTANT PRESSURES FOR VENTILATION

Causes of negativity of I.P.P

Due to inward **recoil tendency** of lungs and outward **expansion tendency** of thorax.

A) Recoil tendency of the lung, is due to:

1) Elastic recoil of the lungs: (**1/3** recoil tendency)

- Relaxation volume of the **lung** = **1** liter.
- At **end of normal expiration** it becomes **2.5 L**, Thus it tends to recoil inwards → to **1** L.

2) Surface tension: (**2/3** recoil tendency)

Causes of negativity of I.P.P

B) Expansion tendency of thorax :

- Relaxation volume of the **thorax** = **5** liters.

- At **end of normal expiration** it becomes **2.5** liters, Thus it tends to expand outwards→ to **5** L.

Significance of negativity of I.P.P :

1) Expansion of the lung.
2) Venous return.
3) Lymph flow in the thoracic duct.
4) Deglutition.
5) Pulmonary blood flow.

Causes of positivity of IPP:

1) Forced expiration (Physiological).
2) Pleural effusion.
3) Emphysema→ (Pathological).
4) Pneumo ,Pyo, haemo, chylothorax.

IMPORTANT PRESSURES FOR VENTILATION

Transmural Pressure Gradient

Pressure across the lung wall (Transpulmonary pressure)

= pressure inside the lungs - pressure just outside it

= intra-alveolar pr – intra-pleural pr

= 760- 756 = **4 mm Hg.**

It keeps the alveoli open (**distending pressure**)

Pressure across thoracic wall (Transthoracic pressure)

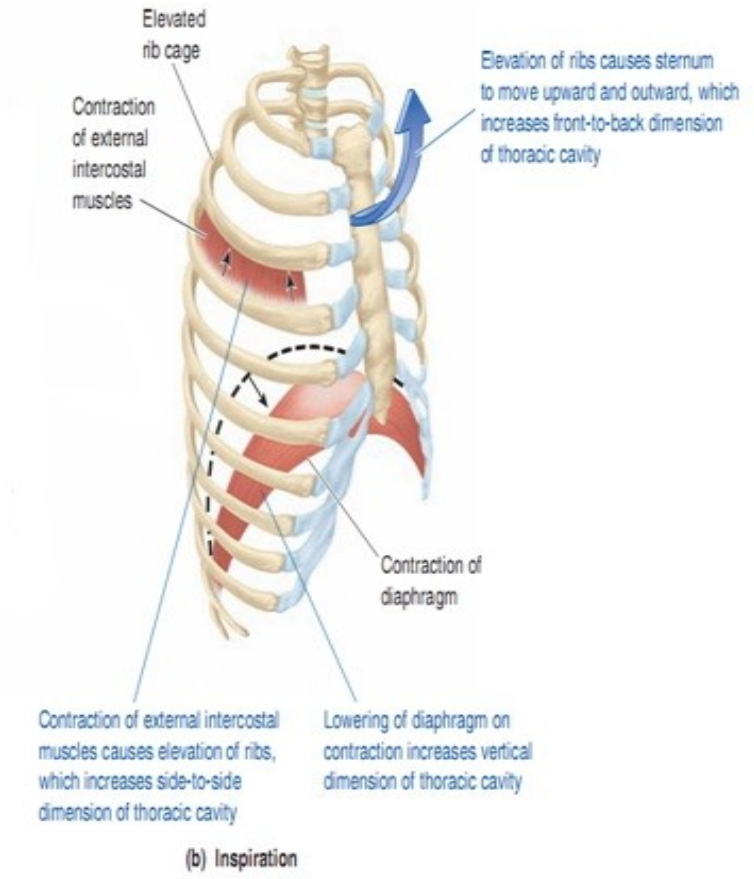
= intra-pleural pr – atmospheric pressure

= 756-760 = **-4 mm Hg.**

It pushes inward on thoracic wall (**compressing pressure**)

Mechanics Of **Normal Inspiration**

1. Normal quiet breathing is accomplished by contraction of diaphragm and external intercostal muscles.
2. ↑ volume of thorax.
3. ↓ intra-pleural.
4. ↑ volume lung.
5. ↓ intra- alveolar pressure
6. Air flows in alveoli according to pressure gradient



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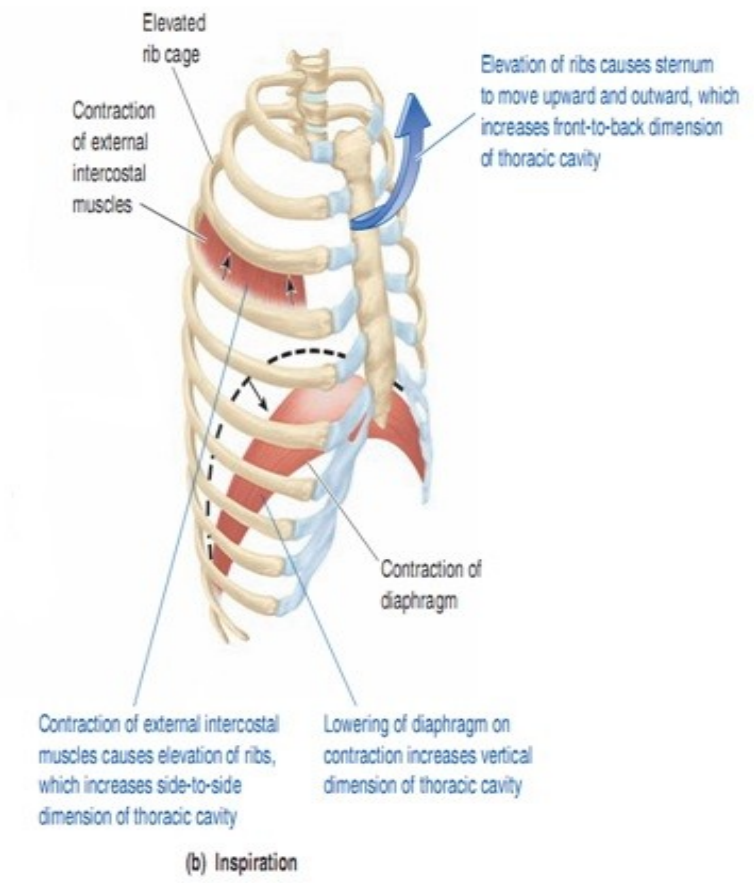
Mechanics Of **Forced Inspiration**

1. **Strong** contraction of diaphragm and external intercostal muscles
2. Contraction of accessory inspiratory muscles.
3. More decrease in intra-alveolar pressure and more air flow will enter the lung.



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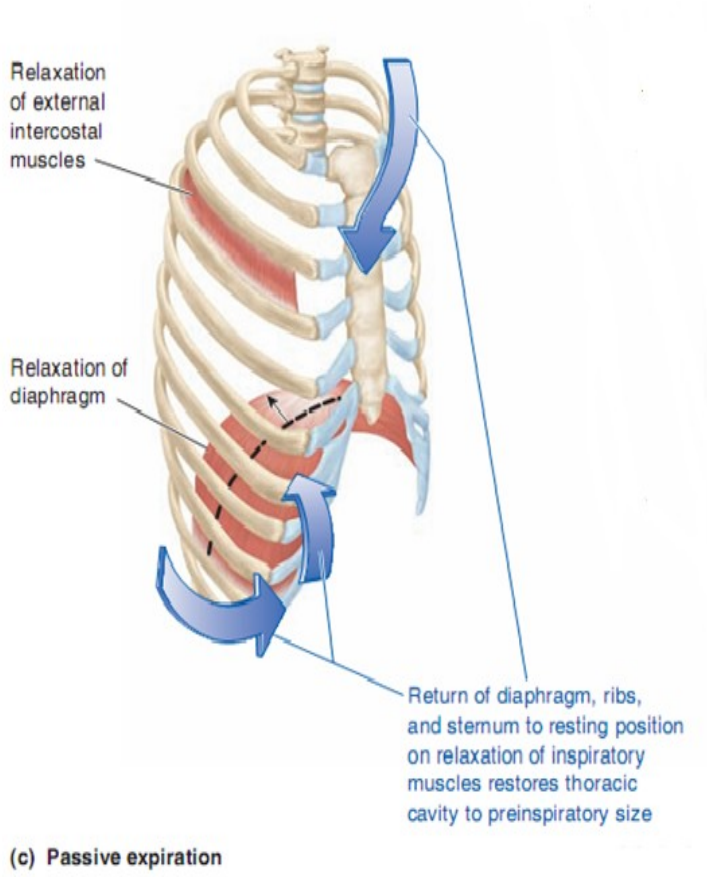
Mechanics Of **Normal Expiration**

Quiet expiration is a passive process

1. **Relaxation** of the diaphragm and external intercostal muscles.
2. Chest wall recoil to pre-inspiratory position.
3. ↓ thoracic volume
4. ↑ intra-pleural pressure.
5. ↓ lung volume.
6. ↑ intra-alveolar pressure.
7. Air leave the lung down the pressure gradient.



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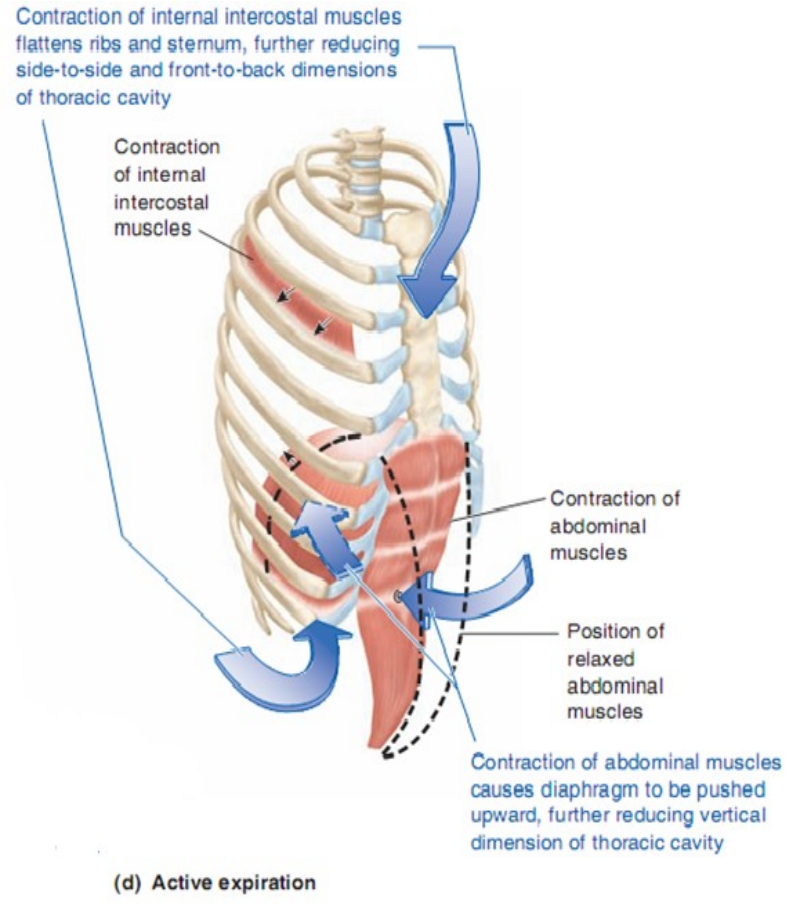
Mechanics of forced expiration

It is an active process

1. Contraction of the expiratory muscles (abdominal and internal intercostal muscles.
2. Further decrease in thoracic dimension with more reduction in lung volume.
3. Increase the intra-alveolar pressure more than in quiet expiration
4. Forcing more air to exit from the lung



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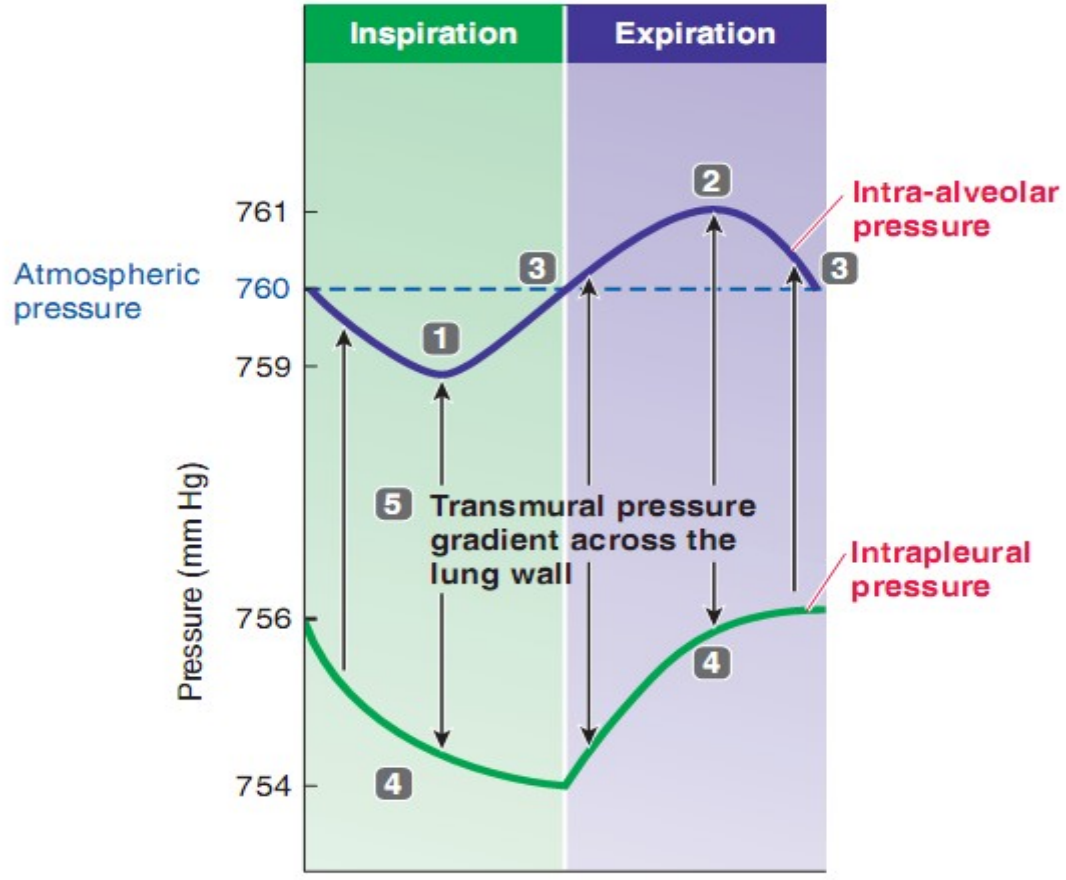
Pressures that cause the movement of air in and out of the lungs



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Lecture Quiz

1- Contraction of the diaphragm would cause:

A. An increase in intra-pulmonary pressure.
B. An increase in airways pressure.
C. A decrease in intra-pulmonary pressure.
D. A decrease in intra-abdominal pressure.
E. A decrease in transpulmonary pressure

Lecture Quiz

2- The main inspiratory muscle is:

A. External intercostal.
B. Abdominal muscle.
C. Internal intercostal.
D. Sternomastoid.
E. Diaphragm.

SUGGESTED TEXTBOOKS

1. Guyton and Hall textbook of medical physiology, thirteenth edition 2016 by Elsevier chapter 38 , from page 497 to 499

2. Ganong's Review of Medical Physiology, twenty-fifth edition 2016 by McGraw-Hill Education, chapter 34, from page 624 to 628

3. Human Physiology: From Cells to Systems, Ninth edition 2016. by CENGAGE, chapter 13, from page 450 to 456 Lauralee Sherwood

Thank You